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The Patent Office

Cardiff Road
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1. Your reference — CTV/P104755GB

2. Patent application number *(The Patent Office will fill in this part)* — 0400925.4 — 16 JAN 2004

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   Antenova Limited
   Far Field House
   Albert Road
   Stow-cum-Quy
   Cambridge
   CB5 9AR

   Patents ADP number *(if you know it)* — 8044505003

   If the applicant is a corporate body, give the country/state of its incorporation — UK

4. Title of the invention — A dual band diversity WLAN antenna system for laptop computers, printers and similar devices

5. Name of your agent *(if you have one)* — Harrison Goddard Foote

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   Belgrave Hall
   Belgrave Street
   Leeds
   LS2 8DD

   Patents ADP number *(if you know it)* — ~~14571001~~ 7631310002

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
   a) any applicant named in part 3 is not an inventor, or
   b) there is an inventor who is not named as an applicant, or
   c) any named applicant is a corporate body.
   See note (d))

   Yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	0
Description	8
Claim *(s)*	1
Abstract	0
Drawing *(s)*	0

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Priority documents	0	
Translations of priority documents	0	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	0	
Request for preliminary examination and search *(Patents Form 9/77)*	1	
Request for substantive examination *(Patents Form 10/77)*	0	
Any other documents *(please specify)*	1	Cover letter, fee sheet

11. I/We request the grant of a patent on the basis of this application.

Signature

Date 16-1-04

12. Name and daytime telephone number of person to contact in the United Kingdom Chris Vaughan 0113 233 0100

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DUPLICATE

A Dual Band Diversity WLAN Antenna System for laptop computers, printers and similar devices

Vijay Nahar & Brian Collins

Summary

The present invention relates to a novel antenna, which may cover the frequency bands used for IEEE802.11a/b/g wireless LANs, comprising a dual-band radiator coupled to a microstrip transmission line by means of a shaped ceramic pellet. The device is designed to be fitted into the display section of laptop computers, but may also find applications in devices that communicate with computers such as printers, and the like. The devices are designed to operate in pairs with good isolation between them, so as to create diversity in the antenna system.

Introduction

The introduction of wireless LAN connectivity has created a demand for compact low-cost antennas covering the frequency bands 2.4 – 2.5GHz and 4.9 – 5.9GHz. These are typically fitted to laptop computers and PDAs, and they will soon be found in printers, scanners and other peripheral devices.

The essential properties for these antennas are high efficiency, and radiation patterns which are as nearly omnidirectional as possible – even when mounted on the target device. These electrical parameters must be combined with physically small dimensions and the potential for production at very low cost. Most antennas will be directly connected to a sub-miniature coaxial cable and the antenna design must embody a suitable means of attachment that will control the placement of the cable accurately enough to ensure good repeatability of input matching.

Dual Band Antenna Structure

According to the present invention, there is provided a dual band antenna device comprising a dielectric substrate having opposed first and second surfaces, a groundplane on the second surface, a microstrip transmission line on the first surface, a dielectric pellet on mounted on the first surface on the microstrip transmission line, and a bifurcated planar inverted-L antenna (PILA) component mounted on the first

surface, the PILA component having first and second arms which extend over and contact a surface of the dielectric pellet, the first arm contacting a different area of the surface of the dielectric pellet than the second arm, the PILA also being electrically connected to the groundplane.

The dielectric substrate may be in the form of a printed circuit board (PCB) with a metallised (generally copper) groundplane. A particularly preferred dielectric substrate is a Duroid® PCB.

The dielectric pellet is preferably made of a high permittivity ceramics material, for example having a relative permittivity of around 6.

The ceramic pellet is preferably an elongate oblong with a generally flat upper surface (i.e. the surface of the pellet distal from the first surface of the dielectric substrate), and in a particularly preferred embodiment is formed as a bridge structure such that it contacts the microstrip transmission line only at its ends.

The bifurcated PILA is preferably arranged substantially in line with the elongate ceramic pellet, and the first arm of the PILA preferably extends across and contacts an entire length of the upper surface of the ceramic pellet, while the second arm of the PILA is preferably shorter than the first arm and contacts only one small part of the upper surface of the ceramic pellet. An end of the PILA distal from the arms may connected to the groundplane by way of conductive pins that pass through the dielectric substrate.

In contrast to traditional dielectric resonator antenna (DRA) structures, where the ceramic pellet (the resonator) is fed at a single point (e.g. by a probe or slot feed), the ceramic pellet in the present invention is fed along its length where it contacts the microstrip transmission line. The ceramic pellet does not itself radiate significantly, but serves as a dielectric load for the arms of the PILA, which is the main radiating structure.

At lower frequency bands, e.g. 2.4GHz, the first, longer arm of the PILA tends to be the main radiator, and is excited by the electromagnetic field in a corner of the ceramic pellet near the end of the first arm.

At higher frequency bands, e.g. 5.5GHz, the second, shorter arm of the PILA tends to be the main radiator, and is excited by the electromagnetic field in a corner of the ceramic pellet near the end of the second arm.

Nevertheless, it is to be appreciated that the whole of the ceramic pellet can excite the PILA to a greater or lesser extent depending on the frequency and also on specific design factors.

By exciting the two arms of the PILA in different ways, the present invention provides a novel dual band hybrid antenna.

In a particular example, shown in Figure 1, the antenna comprises three major components:

Radiating element: This is a narrow quarter-wavelength grounded patch with separate resonators for each frequency band.

Microstrip feed line: The radiating elements are excited from a microstrip feedline entering the structure at the open-circuit end. The feedline incorporates a matched microstrip/coaxial transition to allow the antenna to be fed from a subminiature coaxial cable (1.2mm diameter).

Ceramic pellet: The shaped ceramic pellet ($\varepsilon r = 6$) loads the radiating element, reducing its physical length, and also enhances the coupling between the element and the feedline.

The ceramic component is not functioning as a dielectric resonator antenna (DRA), yet the operation of the structure is strongly dependent upon its presence for reasons

beyond simple dielectric loading; for this reason it is referred to as a hybrid ceramic antenna.

The novelty of the invention lies in the following aspects:

- The element is not a PIFA (a planar inverted-F antenna) with a fixed feed point tapped into the patch or closely capacitivly coupled into the patch, as is usual practice for engineering small patch antennas.
- The element is a PILA (a planar inverted-L antenna) and has no direct feed point. Instead it is excited by the electromagnetic field in a relatively long dielectric ceramic, which is in turn fed by a microstrip transmission line. The arrangement provides a number of additional parameters, such as the shape, dimensions and relative permittivity of the ceramic, and its position relative to both the microstrip-line and the radiating element. The optimisation of these parameters allow the designer substantial choice in the performance of the antenna, as can be seen by the example.
- The feed is arranged to be at the open end of the PILA, where for a conventional feed the impedance would be very high and the antenna would be difficult to feed.
- The PILA is bifurcated (not novel in itself) but the novel elongated dielectric feed is an effective drive for both arms of the PILA, driving each at the appropriate frequency.

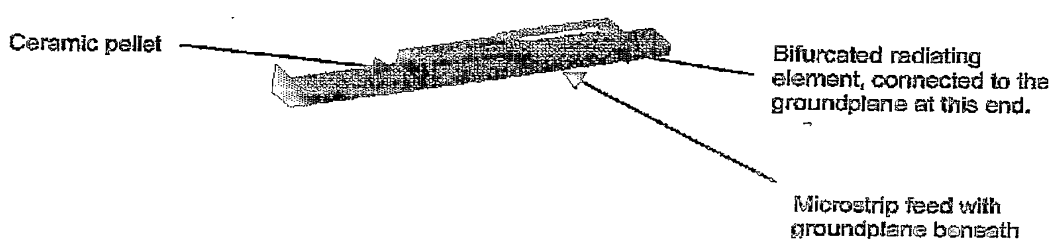

Figure 1. Dual Band hybrid Loaded PILA

Simulated Results

Initial development of the antenna was carried out using the Ansoft 3D electromagnetic simulator, HFSS. The computer simulation results showed good return loss at the desired frequency bands. The simulation also confirmed the effective and independent operation of the two sections of the radiating element and allowed the optimisation of the size, shape and permittivity of the ceramic pellet. Figures 2 and 3 show the expected field distributions at the middle of the two operating frequency bands.

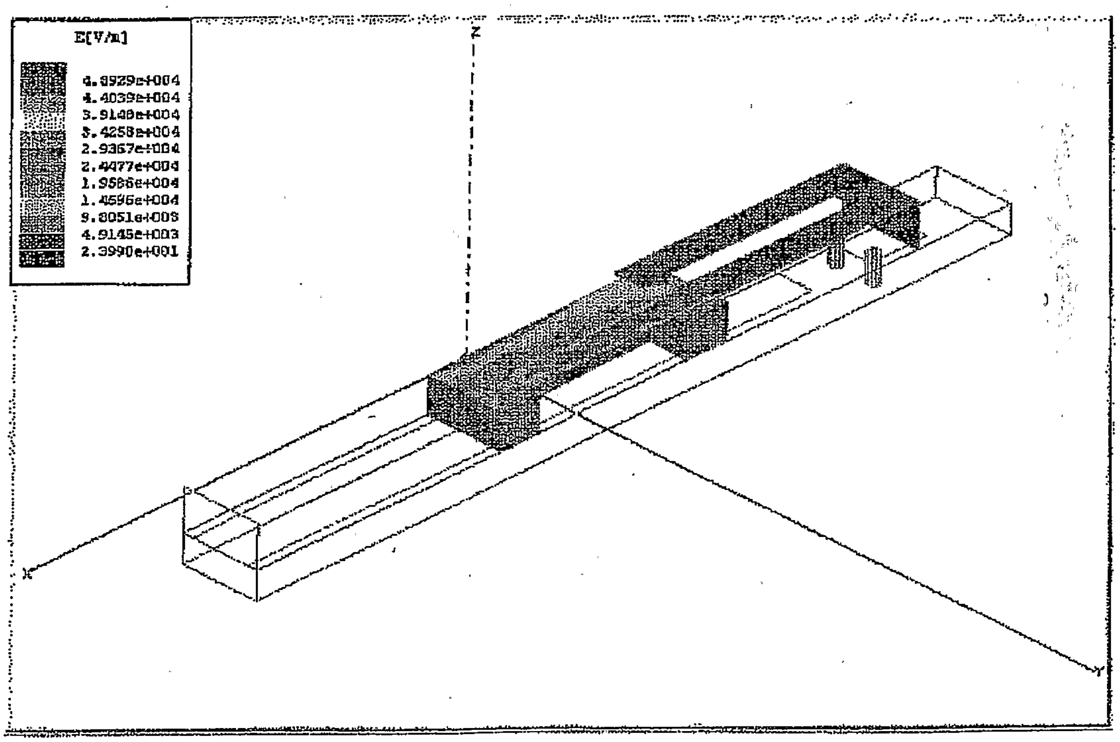

Figure 2. E-field plot at 2.4GHz Band

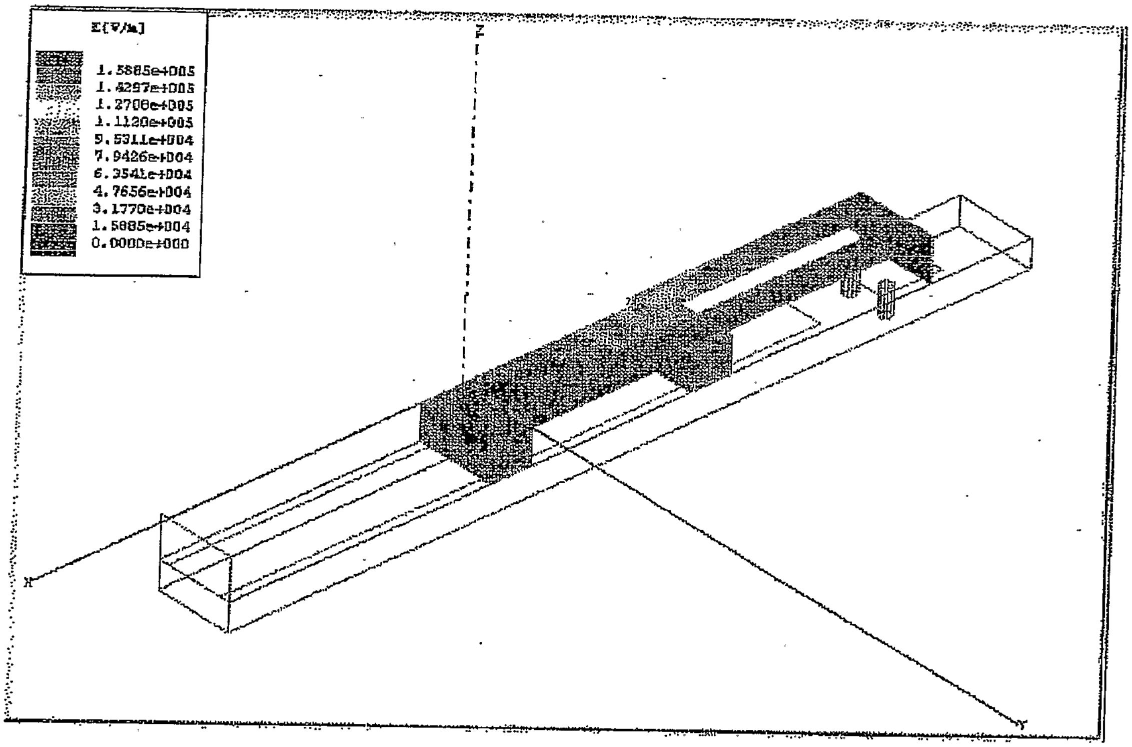

Figure 3. E-field plot at 5.5GHz Band

Measured results

Input return loss The measured input return loss of the complete antenna and its feed cable is shown in Figure 4. The small ripples in the measurement are caused by a mismatch at the measurement point, a familiar problem when working with subminiature cables at high frequencies.

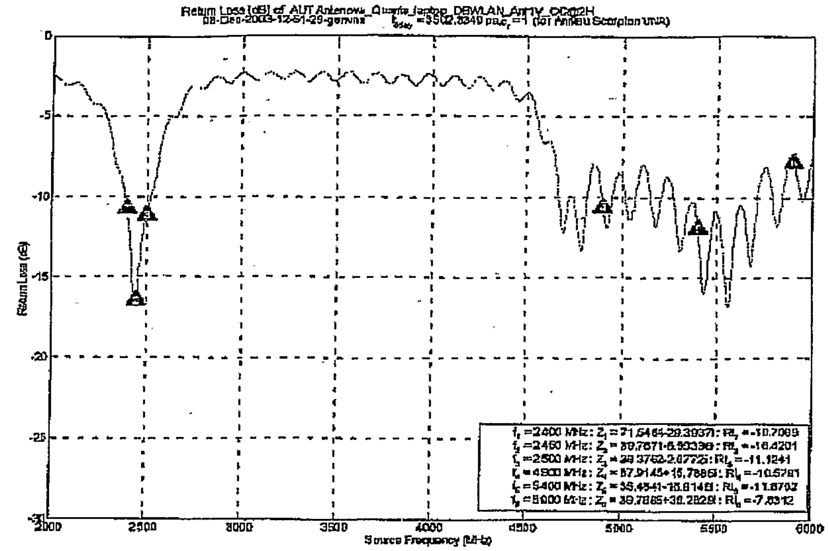

Figure 4. Measured return loss plot

It can be seen that the design has been optimised to provide a much wider bandwidth at 5GHz than at 2.5GHz, corresponding to the requirement. In a practical application, compensating the connector discontinuity within the connected device can reduce the input-end mismatch and corresponding ripple, allowing the target return loss of 10dB to be achieved across both bands.

To investigate isolation performance, a pair of antennas was mounted in a typical laptop application on the top of the display with a spacing of 75 mm between them. It can be seen that the isolation between the antennas is around 20 dB in the low band (where the antennas are electrically closer together) and 40 dB in the high.

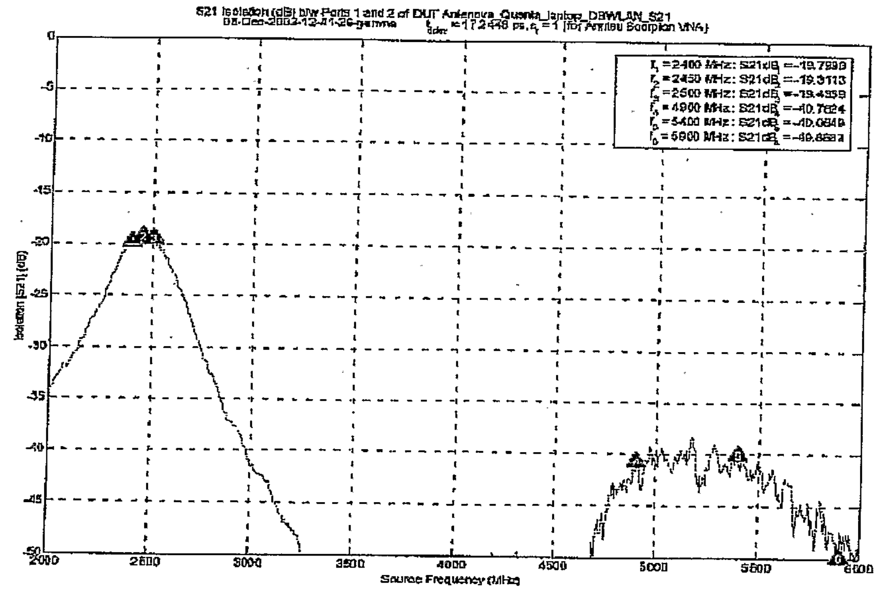

Figure 5. Isolation between a pair of antennas spaced 180 mm part

The preferred features of the invention are applicable to all aspects of the invention and may be used in any possible combination.

Throughout the description and claims of this specification, the words "comprise" and "contain" and variations of the words, for example "comprising" and "comprises", mean "including but not limited to", and are not intended to (and do not) exclude other components, integers, moieties, additives or steps.

CLAIMS:

1. A dual band antenna device comprising a dielectric substrate having opposed first and second surfaces, a groundplane on the second surface, a microstrip transmission line on the first surface, a dielectric pellet on mounted on the first surface on the microstrip transmission line, and a bifurcated planar inverted-L antenna (PILA) component mounted on the first surface, the PILA component having first and second arms which extend over and contact a surface of the dielectric pellet, the first arm contacting a different area of the surface of the dielectric pellet than the second arm, the PILA also being electrically connected to the groundplane.

2. A device as claimed in claim 1, wherein the dielectric pellet is made of a high permittivity ceramics material.

3. A device as claimed in claim 1 or 2, wherein the dielectric pellet is an elongate structure with a generally flat exposed surface facing away from the first surface of the dielectric substrate.

4. A device as claimed in claim 3, wherein the dielectric pellet is formed as a bridge structure with first and second feet that contact the microstrip transmission line.

5. A device as claimed in claim 3 or 4, wherein the bifurcated PILA is arranged substantially in line with the elongate dielectric pellet, and wherein the first arm of the PILA extends across and contacts substantially a full length of the upper surface of the dielectric pellet, while the second arm of the PILA is shorter than the first arm and contacts a smaller part of the upper surface of the ceramic pellet.

6. A dual band antenna device substantially as hereinbefore described with reference to or as shown in the accompanying drawings.

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